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ABSTRACT

As the nation's schools respond to calls for improved science education, educators are faced with the challenge of making what is learned in the classroom applicable to what is happening in society. This newsletter article discusses constructive and erroneous definitions of science, identifies several national reform efforts in the area of science education, and describes four exemplary science programs, at high schools in Iowa, Wisconsin, Washington State, and New Jersey, respectively. It is concluded that the science encountered in schools has no meaning in the students' regular lives and therefore seems unrelated and useless to them. Science/Technology/Society, a reform effort headquartered at Penn State University, is an effort to cast learning into a real world context where students bring their experiences into the classroom, where students ask questions and find their own solutions and explanations, and where teachers guide students rather than force them along a path. (PR)

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Science/Technology/Society—Addressing the Real Problems in Science Education

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As the nation's schools respond to calls for improved science education, educators are faced with the challenge of making what's learned in the classroom applicable to what's happening in society.

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When President Bush and the nation's governors called for improved science and mathematics education by the year 2000, they proposed three strategies to meet that goal:

1. Strengthen science and math instruction throughout the system with emphasis on the early grades
2. Increase the number of teachers with substantive backgrounds in math and science
3. Increase the number of college/university graduates in science, math, and engineering—especially women and minorities.

In the United States, our major problems in science education include:

- Interest in science declines across the K–12 curriculum; the more a student studies science in the school, the worse his or her attitude about the subject becomes (ETS, 1988; Hueftle, Rakow, and Welch, 1983; NAEP, 1978).
- Nearly 85 percent of the most successful high school graduates (university physics majors and engineering students) cannot relate science concepts and processes to real-world situations (Champagne and Klopfer, 1984; Mestre and Lochhead, 1990).
- Creativity skills related to science (e.g., curiosity, questioning, predicting causes and consequences) decline as a result of typical science instruction (NAEP, 1978).
- Few students—even the most successful—can do anything with the science information and skills they master except repeat them for tests (Mestre and Lochhead, 1990).
- Most teachers (90 percent) remain wedded to their textbooks. Seventy-five percent of U.S. science teachers are satisfied with the existing books and their use (Harms and Yager, 1981; Weiss, 1987).

Defining Science

Simpson (1963) says, "Science is an exploration of the material universe in order to seek orderly explanations (generalizable knowledge) of objects and events; but these explanations must be testable."

Simpson's definition emphasizes the importance of personal experiences: exploring, explaining, and testing. These basic science "activities" make science approachable for everyone, whether or not they have mastered a textbook or a specialized "science" vocabulary. Each step requires personal action, involvement, and thinking.

When science is approached in this way, students are personally involved with thinking and have ample opportunities for increasing their skills with thinking.

Unfortunately, most people see science as special information, i.e., concepts about which scientists agree. They approach "science" in classrooms as something that must be mastered before students can have personal experience in the field. They want to define the science concepts and skills that students must master if they are to be judged as successful science students.

Typical teaching assumes that standard explanations, concepts, and even specialized skills can be taught directly. Such erroneous assumptions about learning stand in the way of meeting our national education goal relative to science education.

For many, the Constructivist Learning Model provides a framework for defining meaningful science learning and for assessing success (Yager, 1991). Basic to the model is the observation that meaning cannot be transmitted, even to willing learners. Instead, all learning must be constructed by each learner.

National Reform Efforts

Several exciting national reform efforts in the area of science education are being implemented, including:

- Project 2061, a gigantic effort sponsored by the American Association for the Advancement of Science (AAAS).
- Scope, Sequence, and Coordination (SS&C), a huge project sponsored by the National Science Teachers Association (NSTA) with rationale provided by the project director (Aldridge, 1989).
- Science/Technology/Society (STS), a reform effort headquartered at Penn State University and supported by two NSF planning and networking projects (Roy, 1991). Separate initiatives focus on materials development, teacher preparation, teacher strategies, community/industrial partnerships, and special programs for underrepresented groups.

NSTA has conducted several searches for exemplary science programs since the initiation of its Search for Excellence in Science Education program in 1982. These searches have enabled us to identify and describe several effective science programs. The examples provide models of what can be done and evidence of the success of strategies other than mastery of concepts.

Generally, the following features characterize exemplary programs that link science, technology, and society:

- Student identification of problems with local interest and impact
- The use of local resources to locate information that can be used in problem resolution
- Active involvement of students in seeking information that can be applied to solve real-life problems
- Extension of learning beyond the class period, the classroom, and the school
- A view that science content is more than concepts that students must master for tests
- An emphasis on career awareness—especially careers related to science and technology
- Opportunities for students to experience citizenship roles as they attempt to resolve issues they have identified
- Identification of ways that science and technology are likely to affect the future
- Some student autonomy for students in the learning process

The following are four examples of science programs that include these features.

Exampli Gratia

AUGUSTA JR.-SR. HIGH SCHOOL
Augusta, Wisconsin 54722
Contact: Ken Stahl, principal; Paul Tweed and Jeff Hadorn, science instructors
(715) 286-2291

Science is research. At Augusta Jr.-Sr. High School, science students in grades 7–10 conduct research into local issues. In grades 11 and 12, advanced science courses integrate investigations into a curriculum based on problem solving.

The advanced curriculum consists of investigation and project-oriented units in which students generate and communicate scientific knowledge and ideas.

Each unit begins with an exploration of questions or problems that face the local environment, community, population, or individuals. Integrating the use of on-line databases, computer networks, and available laboratory instrumentation technology, including quantitative water quality analysis, ozone monitors, climate stations, human physiology computer tools, and the less technological tools and methods of the field scientist, students work through the processes of science on individual and group projects.

The relationship between humans and the local environment is emphasized. Monitoring stations are maintained on the local watershed streams and lake for teaching and research purposes. Both teachers and students identify projects and conduct the research. Summer research programs involve students in long-term research on local issues.

The Augusta program focuses on students as scientists to promote involvement in problem solving on a local level and to build student participation in issues related to science on all levels. Cooperation between middle level and high school classes is common.

DENISON COMMUNITY HIGH SCHOOL
819 North 16th Street
Denison, Iowa 51442
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(712) 263-3101

STS is central to the science program at Denison Community High School, where the STS philosophy is particularly evident in the chemistry and environmental biology classes.

In practice, the STS experience begins with students finding news articles that relate to the subject of the class. Environmental biology students may bring in articles about the rain forest while chemistry students might bring in articles about contamination of the groundwater.

After the articles are shared in class, the students develop lists of issues related to their articles. These

issues are categorized and students vote on which issues will become the basis for classroom investigations.

The students break into groups and develop three questions they intend to investigate.

The investigation differs from a traditional "research project" in that the students are encouraged to utilize local and non-traditional resources. They are also required to add some type of social component to their project, such as developing flyers to be distributed to the public or posters to be displayed in town, or hosting a public forum about the issue they investigated.

Rather than being information providers, teachers are facilitators. Teachers know where the class should be academically at the end of the quarter, semester, or year, but students are empowered to help determine the pace and route of the journey.

The change in the classroom is amazing. The question, "Why do we need to know that?" is replaced with "Did you know that...?" Students are able to learn things on their own with guidance and support from the teacher. Now, in addition to "writing across the curriculum," we can see "science across the curriculum."

MT. BAKER HIGH SCHOOL
P.O. Box 95
Deming, Wash. 98244
Contact: Kenn Robinson, principal; David Tucker, science instructor
(206) 592-5151

The four-year Mt. Baker science program challenges students to change the world outside their classroom. The curriculum framework for each instructional unit consists of:

- An issue-driven topic
- Active learning strategies
- An open-ended laboratory experience
- Conceptual teaching methods
- Elaborate use of technology tools
- Supplemental skills modules for independent study
- Performance-based assessment strategies to match the dimensions above.

Students in the first-year chemistry program focus on six topics during the year, including water quality, garbage chemistry, fuels, global air quality, and materials chemistry. Students in the second year program study toxic substances, alcohol and alcoholism, biological/chemical warfare, pesticides, proteins and DNA, and the quality of life.

Stretching the bounds of the classroom into the community is a common theme. Students learn how to protect a watershed, design and produce a rich compost to sell locally as a comprehensive schoolwide waste recycling program, and monitor local and global air quality problems.

Students have established countywide monitoring programs for zinc along the highways and in garbage landfills, lead from numerous sources, and phosphates in sensitive bodies of water.

The program utilizes technology tools such as computer interface programs, spreadsheets, databases, CD ROM, modem applications, and internal networks to encourage students to pursue their understanding of problems to reachable limits.

Students are required to "work through" a model problem-solving process that requires them to identify and characterize societal problems, develop a plan of action to understand the present situation, and finally define and implement a reasonable solution.

OCEAN TOWNSHIP HIGH SCHOOL
550 W. Park Avenue
Oakhurst, N.J. 07755
Contact: John J. Tighe, principal; Ron Truex, science instructor
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"Contemporary Science," an STS program at Ocean Township High School, is designed to provide non-academic disaffected students as well as college-bound youngsters with a meaningful and positive educational experience in science. The goal is to bridge the gap between science and the citizen in a technological world.

The program is a full-year elective course offered to juniors and seniors. Instruction involves the students in activities and projects that reflect current issues in science, including matter and energy; meteorology; the space program; astronomy; population; alternative energy sources; nuclear energy; effects of substance abuse; remote sensing; endangered species; land use; research skills; and air, water, and noise pollution.

Laboratory work, independent study projects, field trips, and presentation of oral and written reports are integral parts of the course.

A major program goal is to develop scientifically literate citizens. This goal is achieved by continuously infusing study skills such as listening, notetaking, time management, organization, effective writing, critical reading, and assessment. Students prepare research reports on science-related issues four times a year.

With the scientific and technical information learned, students are able to evaluate, make informed decisions, and choose a course of action concerning the issues examined.

The STS program has increased student curiosity about science and stimulated greater interest. The students not only gain an appreciation of their own ability to make informed decisions and judgments about science-related issues, they are encouraged to become actively involved in scientific/technological developments that affect their community.

This approach has tuned in young minds rather than turning them off. Relating science/technology to daily life takes science out of the test tube and places it in the real world.

Conclusion

The science that students encounter in school has no meaning in their daily lives. The information and skills learned cannot be used in any context other than the one in which they were presented. As a result, school science seems to most students as something unrelated, and hence useless to their daily living.

STS is an effort to cast learning into a real world context where students bring their experiences into the classroom, where they ask questions and find their own solutions and explanations, where teachers guide students rather than force them along a path.

The sooner we realize the real nature of our problems in science education, the more likely we are to attain the goals set forth by our political leaders.

We must treat our problems in education as they are in science itself. We must propose possible solutions and then test them in the real world.

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